A CONDITIONAL CONVERGENCE ANALYSIS OF PER CAPITA INCOMES

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Abstract

This paper is devoted to the one of the most important problem of the developing economics: Are there the convergence between countries' per capita incomes? Suggested in the paper approach examines this problem using panel data techniques. Also this paper tries to estimates the alpha coefficient from Coub-Douglas production function.

1 Introduction

One of the most important issues in the theory of economic growth and development is whether there is a convergence among countries' per capita incomes. There are two kinds of convergence as it defined by Marques and Soukiazis [2]:

- Unconditional — all countries do converge to one steady state point, and it is not depend on the countries characteristics.
- Conditional — countries have different levels of technology, investments ratios, population growth rates, saving rates, and etc., thus, they have different steady states, but anyway they do converge to this levels.

Development of panel data techniques allowed to find answer to this question, or, at least, with some confidence to argue whether there is conditional convergence. The main challenge these methods are addressing is whether in the long run there is some permanent gap in incomes of different countries or this gap has characteristics of non-stationary time series.

In this paper I will address the following issues, with help of panel cointegration tests and estimations:

- I will test for conditional convergence between countries incomes holding individual countries' characteristics.
- I will test for conditional convergence among countries incomes holding individual countries' characteristics, and particularly countries' investment shares.
- With help of FMOLS estimates I will find the group mean slope coefficient for regression between income per capita and investment share.

2 Theory

Firstly, let's assume we have Cobb-Douglas production function $Y = K^{\alpha}(L * E)^{1-\alpha}$, or in per effective labor terms $y = A_0 k^{\alpha}$. Let's assume that we have two countries with different values of investment rates (γ_1, γ_2), depreciation of capital rates (δ_1, δ_2), population growth (n_1, n_2), human capital (h_1, h_2), initial technology level (A_{01}, A_{02}), technology growth rates (g_1, g_2) and structure of economy (α_1, α_2) then steady states of capital per capita are defined by the formula:

$$k_{ss}^{(i)} = \Big(\frac{\gamma_i}{n_i + \delta_i + g_i}\Big)^{\frac{\alpha_i}{1-\alpha_i h_i}}, \tag{1}$$

where index i means country (first or second); correspondingly, steady states of the income per capita are defined by the formula:

$$y_{ss}^{(i)} = A_{0i}\Big(\frac{\gamma_i}{n_i + \delta_i + g_i}\Big)^{\frac{\alpha_i}{1-\alpha_i h_i}}. \tag{2}$$

So, the main problem becomes to check for pair-stationarity of difference in income among all countries in the sample. Thus, here we can use panel cointegration tests for unit root, but before this we should formulate the problem we have. Let's assume we have N countries annual data for T periods on income per capita (y_{it}), investment shares (inv_{it}). Then, our problem leads to the checking for pair-stationarity in the following two expressions:

$$(y_{it} - \alpha_i - \overline{y}_t) \sim I(0) \ \text{ for all } i, \tag{3}$$

and

$$\big((y_{it} - \overline{y}_t) - \beta_i(inv_{it} - \overline{inv}_t) - \alpha_i\big) \sim I(0) \ \text{ for all } i. \tag{4}$$

So, in this case we have expression in brackets, which depends only on i, thereafter we can check on stationarity just by imposing unit root test for panel data. If there is heterogeneity in the data (that is true because we will have different countries), we can imply Im, Pesaran, Shin panel root test (IPS test) for expressions defined by (3) or (4).

It can be done by using standard Z-statistic defined in the same way as it is done by Im, Pesaran and Shin [1] or by using Z-statistic calculated accordingly with bootstraping IPS test, based on the approach suggested by Pedroni [5].

Another interesting issue in the Solow model which I tried to address in my research is whether shares of capital used in the economy are different across countries. Let's transform equation (2) by taking logarithm and allowing time dimension:

$$\log(y)_{it} = A_{i0} + \frac{\alpha_i}{1-\alpha_i}\log(\gamma)_{it} + C_i + \varepsilon_{it}. \tag{5}$$

So, if we approximate saving rate by share of investment to GDP we can estimate by this model coefficient α_i, and to check hypothesis if it is the same across countries. However, there are some limitations, which do not allow to apply standard techniques to estimate (5):

- Regular OLS estimation presents superconsistent estimates of slope coefficient, even if series are endogenous; though estimates of standard errors are inconsistent, thus we cannot test for significance of slope coefficient.
- Because of heterogeneity both in series and dynamics, there can be dependence between residuals and standard errors, so, their estimation can be also biased.

However, these shortcomings can be adressed through the FMOLS group mean estimation, which can be used for estimation the slope coefficient in the long run relationship between income per capita (y_{it}) and investment shares (γ_{it}).

3 Empirical results and their interpretation

I provided all estimation on data for 1950–2009 for 37 countries and found set of interesting results, which with some assumptions confirms the theoretical suggestions.

Firstly, I checked whether series for output per capita and share of investment in GDP (estimation of saving rate) are stationary, or do they have unit root. IPS regular test rejects reject the hypothesis that investment shares (Inv) series has unit root in both cases, when series are detrended and not. However, bootstrapped IPS test cannot reject hypothesis about unit root in Inv series. It can be explained by the fact, that the length of time period is pretty small (60 dots), and implying of tabular μ and ν values significantly distorts the Z-statistic of test. For bootstrapped IPS test, applied for both detrended and regular series Inv, are equal to minus 0.45 and minus 0.52 correspondingly. Thus, we can with some confidence level say that Inv series is $I(1)$, that means there is no convergence between countries investment levels.

Secondly, test for convergence of incomes based on regular IPS test for non-detrended GDP per capita (y) series shown that y is $I(1)$ series and hypothesis about convergence of incomes can be rejected. Results of bootstrapped IPS test also confirm this conclusion. However, if we take into account fixed countries' specific effects hypothesis about convergence of incomes can't be rejected both for standard IPS test and for bootstraped IPS test.

Thirdly, I checked whether cointires incomes do converge conditional on investments shares and human capital level. For these reasons I applied Pedroni test [4] to check possibility of cointegration between detrended series y and Inv, including in the test heterogeneity for catching differences in the human capital according to the formula (5). The t-statistic of ADF test is equal to minus 1.7, and it allows us with 95% percent confidence argue that there is convergence of incomes conditional on fixed effect and investment shares (individually, many countries also reject hypothesis about divergence, some even with 99 percent confidence). So, I confirm the theory of Solow model, but this approach also allows us to find estimation of slope coefficient between y and Inv series to receive estimation of α-coefficient from Solow model.

Therefore, using FMOLS approach [3] I received that group estimation of the slope from formula (5) is equal to 0.83 and t-statistic is equal to minus 7.8. Thus, it allows to argue that hypothesis that the slope coefficient is equal among all countries can be rejected at 1% level. General FMOLS estimation of α is equal to 0.45, which is

different from usually used value in regular OLS estimation of Solow model, which is equal to 0.66.

4 Conclusions

In this paper I was checking the most discussed hypothesis of classical theory of economic growth:

- Is there convergence of incomes among countries?
- Do countries have common value for coefficient α from the Solow model, which determined structure of economy?
- Is this value is different from the most popular, which is equal to 0.66?

I found, that there is convergence of incomes, but it is conditional on fixed countries effects and investment shares, but there is divergence if we control only for fixed effects. It allows to say that structure of economy is changing in the long run. Moreover, I can assume that controlling for particular countries effects, as population growth and depreciation of capital (unfortunately, technology growth is unobservable), which in the long run can also change will give results that allows to make conclusion with much more confidence than 95%, received in the current research.

I also found that the hypothesis about equal slope in the regression between incomes per capita and investment shares can be rejected at 1% level. It allows to say that countries have different values of coefficient α from Solow model, which is determined by the slope coefficient from this regression. Moreover, its FMOLS estimation is different from usually used in the regular OLS estimation of Solow model 0.66, and is equal to 0.45.

References

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